

obtain average magnitude versus frequency data; comparing the [resolved detected scattered energy] average magnitude versus frequency data with a standard; and acting to control the number of particles having a particle size corresponding to the selected incremental frequencies.

25. (Amended) A method as set forth in claim 24, wherein the [frequency range] selected frequencies [for detecting scattered acoustic energy is] are limited to a frequency range of acoustic energy scattered by the agglomerated asphaltene particles characteristic of the oil.

26. (Amended) A method as set forth in claim 24, wherein the [selected] scattered acoustic energy is detected over a frequency range [is] of from about 14 MHz to about 20 MHz.

Remarks

Formal drawings will be submitted upon receipt of an indication that the current informal drawings are otherwise acceptable. Fig. 7 in particular had been objected to. Enclosed is a copy of Fig. 7 showing Applicant's proposed amendment in red. Approval of this correction is respectfully requested.

Claim 21 has been rejected under 35 U.S.C. §112, second paragraph as being unclear as to whether step (b) and following are to be applied to the oil or to the sample. Claim 21 has been amended and it is submitted that the claim as amended clearly points out that step (b) is to be carried out on the sample. Accordingly, withdrawal of the noted rejection of claim 21 is respectfully requested.

Claims 1, 15-17, 21 and 24 have been amended to set forth more specifically and clearly the method of the invention as described at pages 16-21 of the specification and illustrated schematically in Fig. 4.

Reconsideration of the rejection of claims 1-19 as being obvious over the de Boer reference in view of the Gopinathan patent also is respectfully requested. Claim 1 as amended calls for the method for measuring the agglomerative state of asphaltenes in oil containing asphaltenes to comprises applying to the oil a series of pulses of acoustic energy. Each pulse comprises acoustic energy over a range of frequencies. At least a part of the energy is thereby scattered. Further, according to claim 1 as amended, the scattered acoustic energy is detected for each of a plurality of pulses in the series to produce amplitude versus time data. The amplitude versus time data is then resolved to obtain a magnitude of the detected scattered acoustic energy at selected frequencies. The magnitude for each pulse at each selected frequency is then

averaged over the plurality of pulses and the agglomerative state of the asphaltenes is determined from the averaging. Claims 2-19 depend from claim 1 and so include the same steps. In short, therefore, claims 1-19 as amended call for applying a series of pulses of a range of frequencies of acoustic energy to the oil, detecting the resulting scattered energy over a range of frequencies for each of a plurality of the pulses to produce amplitude versus time data, which is then resolved to obtain magnitude versus frequency data, which are then averaged. The agglomerative state is then determined from that averaging.

By contrast, the de Boer method involves simply receiving the back-scattering of short bursts of acoustic energy and converting it into a read-out signal that is sorted by a multi-channel analyzer into amplitude classes corresponding to particle sizes. Thus, the de Boer method is a simple sorting of amplitude classes with little if any further description. De Boer does not disclose or suggest applying a series of pulses, each of which covers a range of frequencies of acoustic energy. Nor does it disclose or suggest producing amplitude versus time data. Nor does it disclose or suggest resolving the amplitude versus time data to obtain magnitude versus frequency data. Nor does it disclose or suggest averaging the magnitude versus frequency data. Nor does it disclose or suggest determining the agglomerative state from that averaging. Instead, de Boer uses a multi-channel analyzer into amplitude classes corresponding to particle sizes, thus pre-supposing certain relative particle sizes and relationship between amplitude and particle sizes. Accordingly, the de Boer method is very different from that of the present claims.

By contrast, Applicants have found that the relationship between amplitude and particle size is not so straightforward. Instead, Applicants have found that the particle size depends on frequency and that the amplitude at that frequency relates to the concentration of particles of a size corresponding to that frequency, but not for a single pulse of energy. Applicants also have found that basing the relationship on a single pulse of energy can result in erroneous readings, perhaps due to the orientation of particles at that time of that pulse. However, Applicants have found that a highly accurate reading can be produced by applying a series of pulses, detecting for each of those pulses the back-scattered energy, resolving the data derived from those detections such as by a Fourier transform and then averaging the resolved data over the series. De Boer nowhere teaches or suggests such steps.

The Gopinathan patent does not make up for such deficiencies. The Gopinathan patent describes a method and apparatus very different from those disclosed by de Boer or the present

application. The method of the present invention, which determines a particle size distribution for any number of sizes of particles found in a fluid such as oil. The method is flexible in that it applies to particles of numerous non-predetermined sizes and that are found inherently in the oil. The method does not change the particles or the oil tested. Thus, it can even be placed on-line without interfering with the oil composition or flow.

By contrast, the Gopinathan method is a limited technique for assaying a limited number of analytes --preferably up to four analytes-- in a liquid sample. The Gopinathan method employs a reagent including a first class of particles that are dimensioned within a predeterminedly narrow range of particle diameters and are coated with a reactant capable of entering into a reaction involving the analyte so as to generate particles of different dimensions than those of the original classes and of characteristic acoustic scattering cross sections, and a second reagent including a second class of particles that are substantially larger than those of the first class and are coated with the noted reactant. Gopinathan forms a mixture of the reactant coated particles of the two classes with the sample to be tested so as to cause a specific reaction involving the reactant and the analyte to form conjugates of the first and second classes of particles. The conjugates have characteristic acoustic scattering cross-sections and irradiating them with compressional waves in a predetermined frequency range causes a reduction in forward energy of the waves, which is then detected. Clearly, this technique is completely different from either the de Boer method or the present method. And while the de Boer and present methods need not alter or interfere with the fluid being analyzed, the Gopinathan method causes a reaction in the fluid. The Gopinathan method would have to be carried out by extraction of a sample or it would contaminate the process flow stream. It is not seen how the Gopinathan disclosure could be combined with the de Boer teaching at all. And unlike the claimed method, the Gopinathan method does not resolve amplitude versus time data to magnitude versus frequency and average the magnitudes. Thus, claims 1-19 distinguish patentably over the de Boer reference in view of the Gopinathan patent.

Favorable reconsideration is also respectfully requested of the rejection of claims 1-11, 15-22 and 24-26 under the judicially created doctrine of obviousness-type double patenting over claims 1-20 of U.S. patent 5,969,237. As amended, all claims of the present application now call for averaging the magnitude versus frequency data. None of the claims of the cited patent refer to any manipulation of the magnitude versus frequency data. As noted above, it has been found

that basing the relationship on a single pulse of energy can result in erroneous readings, perhaps due to the orientation of particles at that time of that pulse. However, Applicants have found that far more accurate readings can be produced by applying a series of pulses, detecting for each of those pulses the back-scattered energy, resolving the data derived from those detections such as by a Fourier transform and then averaging the resolved data over the series. The claims of the cited U.S. patent nowhere teach or suggest that repeated pulses would do more than simply duplicate the original data, or that averaging the resolved results therefrom would improve the measurement of the agglomerative state. Thus, it is submitted that claims 1-11, 15-22 and 24-26 distinguish patentably over the cited U.S. patent.

In view of the foregoing, favorable reconsideration and early allowance of the subject application are earnestly solicited.

Respectfully submitted,


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CLAIMS AS AMENDED

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1. (Amended) A method for measuring the agglomerative state of asphaltenes in oil containing asphaltenes, comprising applying to the oil a series of pulses of acoustic energy, each pulse comprising acoustic energy at multiple frequencies, thereby scattering at least part of the energy; detecting, for each of a plurality of pulses in the series, the scattered acoustic energy to produce amplitude versus time data; resolving the amplitude versus time data to obtain a magnitude of the detected scattered acoustic energy at selected frequencies; averaging over the plurality of pulses the magnitude for each pulse at each selected frequency; and determining from the averaging the agglomerative state of the asphaltenes.

2. (Amended) A method as set forth in claim 1 wherein the selected frequencies comprise at least three different frequencies.

3. (Amended) A method as set forth in claim 1 wherein the selected frequencies comprise at least fifteen different frequencies.

7. (Amended) A method as set forth in claim 6, wherein the scattered acoustic energy is detected over a frequency range of from about 0.1 MHz to about 20 MHz.

A2
8. (Amended) A method as set forth in claim 7, wherein the scattered acoustic energy is detected over a frequency range of from about 0.1 MHz to about 200 MHz.

9. (Amended) A method as set forth in claim 8, wherein the scattered acoustic energy is detected over a frequency range of from about 14 MHz to about 20 MHz.

A3
15. (Amended) A method as set forth in claim 1, wherein the resolving of the amplitude versus time data comprises gating the detected scattered acoustic energy to that part of the detected energy emanating from a focal region and Fourier transforming the amplitude versus time data into a magnitude vs. frequency format.

16. (Amended) A method as set forth in claim 1, wherein the pulses of acoustic energy are applied as a tone-burst and the step of resolving of the amplitude versus time data comprises detecting the magnitude of the scattered energy at selected frequencies.

17. (Amended) A method as set forth in claim 1, wherein the averaging over the series of pulses the magnitude for each pulse at each selected frequency produces an average of the magnitude for each selected frequency, and the determining of the agglomerative state of the asphaltenes is effected by comparing the that average for each selected frequency with a standard.

21. (Amended) A method for measuring the agglomerative state of asphaltenes in an oil containing asphaltenes comprising:

- a. removing a sample of the oil and without diluting the oil;
- b. applying to the sample a series of pulses of acoustic energy, each pulse comprising acoustic energy at multiple frequencies, thereby scattering at least part of the energy;
- c. detecting, for each of a plurality of pulses in the series, the magnitude of the scattered acoustic energy at selected frequencies to produce amplitude versus time data;
- d. resolving the amplitude versus time data to obtain a magnitude of the detected scattered acoustic energy at selected incremental frequencies;
- e. averaging over the plurality of pulses the magnitude for each pulse at each selected frequency;
- f. deriving from the averaging a distribution of the relative size of asphaltene particles scattering acoustic energy; and
- g. determining the agglomerative state of the asphaltene particles.

24. (Amended) A method for controlling the agglomeration of asphaltenes in oil which comprises applying a series of pulses of acoustic energy to the oil, each pulse comprising acoustic energy at multiple frequencies, thereby scattering at least a part of the energy; detecting, for each of a plurality of pulses in the series, the scattered energy at selected frequencies to produce amplitude versus time data; resolving the amplitude versus time data to obtain a magnitude of the detected scattered energy at selected incremental frequencies; averaging over the plurality of pulses the magnitude for each pulse at each selected frequency to obtain average magnitude versus frequency data; comparing the average magnitude versus frequency data with a standard; and acting to control the number of particles having a particle size corresponding to the selected incremental frequencies.

25. (Amended) A method as set forth in claim 24, wherein the selected frequencies are limited to a frequency range of acoustic energy scattered by the agglomerated asphaltene particles characteristic of the oil.

26. (Amended) A method as set forth in claim 24, wherein the scattered acoustic energy is detected over a frequency range of from about 14 MHz to about 20 MHz.

FIGURE 7.

